US006694369B1

(12) **United States Patent**
Vepa et al.

(10) **Patent No.: US 6,694,369 B1**
(45) **Date of Patent: Feb. 17, 2004**

(54) **TAG ECHO DISCOVERY PROTOCOL TO DETECT REACHABILITY OF CLIENTS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/539,923**

(22) Filed: **Mar. 30, 2000**

(51) **Int. Cl.**[7] **G06F 15/16**; G06F 15/177
(52) **U.S. Cl.** **709/228**; 709/221; 709/203
(58) **Field of Search** 709/221, 228, 709/223, 225, 220; 370/254, 401, 466, 255; 713/1

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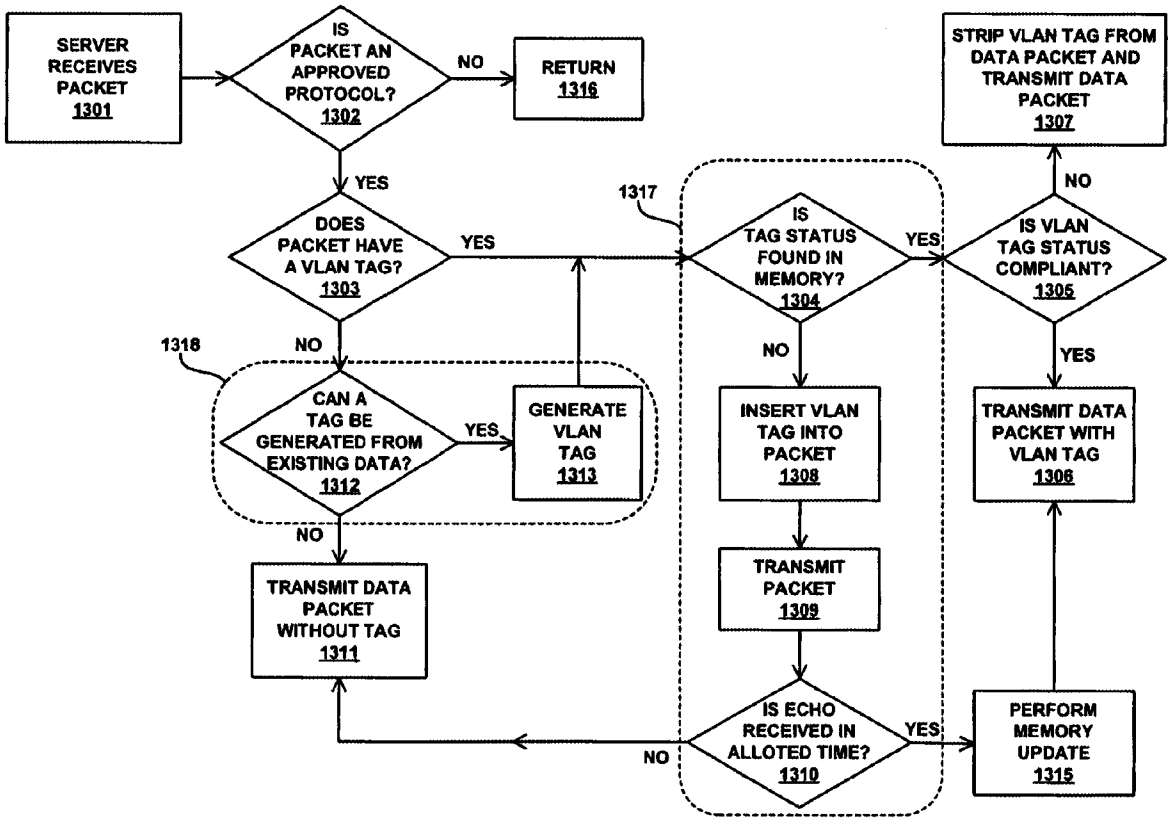
Primary Examiner—David Wiley
Assistant Examiner—Michael Delgado

(57) **ABSTRACT**

A method for detecting reachability of client computers communicatively coupled in a computer network to a server computer. A plurality of identifier tags are resident in the memory of the server. The server generates a data packet comprising an I.C.M.P. echo packet and selects a first identifier tag from among the plurality of identifier tags resident in memory, the first identifier tag being chosen to correspond to a first client computer. The server inserts the first identifier tag into the proper data segment of the echo packet and forwards the packet to the first client. After a predetermined time awaiting a responsive ping from the client, the server determines if the client is tag-compliant or non tag-compliant.

26 Claims, 12 Drawing Sheets



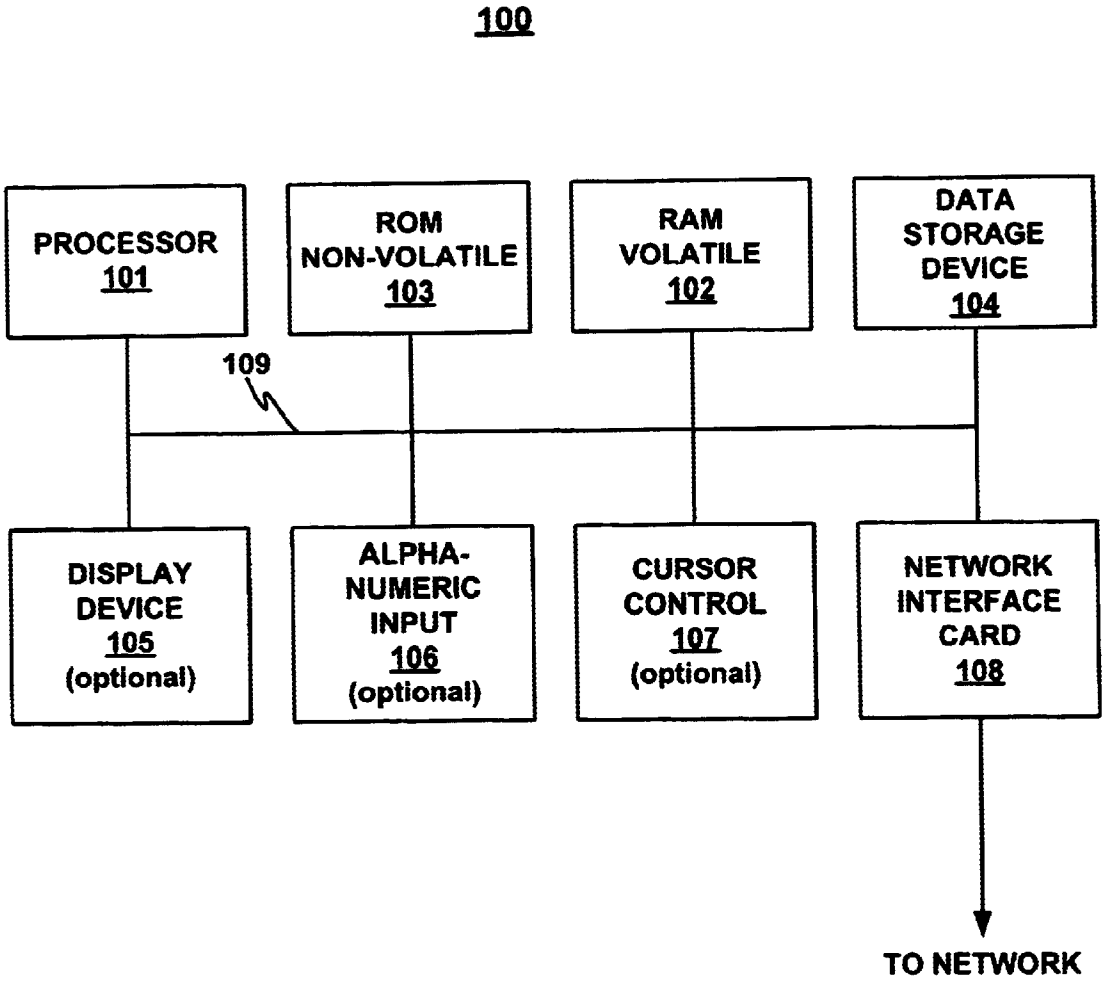

100
PROCESSOR
101
ROM
NON-VOLATILE
103
RAM
VOLATILE
102
DATA
STORAGE
DEVICE
104
109
DISPLAY
DEVICE
105
(optional)
ALPHA-
NUMERIC
INPUT
106
(optional)
CURSOR
CONTROL
107
(optional)
NETWORK
INTERFACE
CARD
108
TO NETWORK

FIG. 1

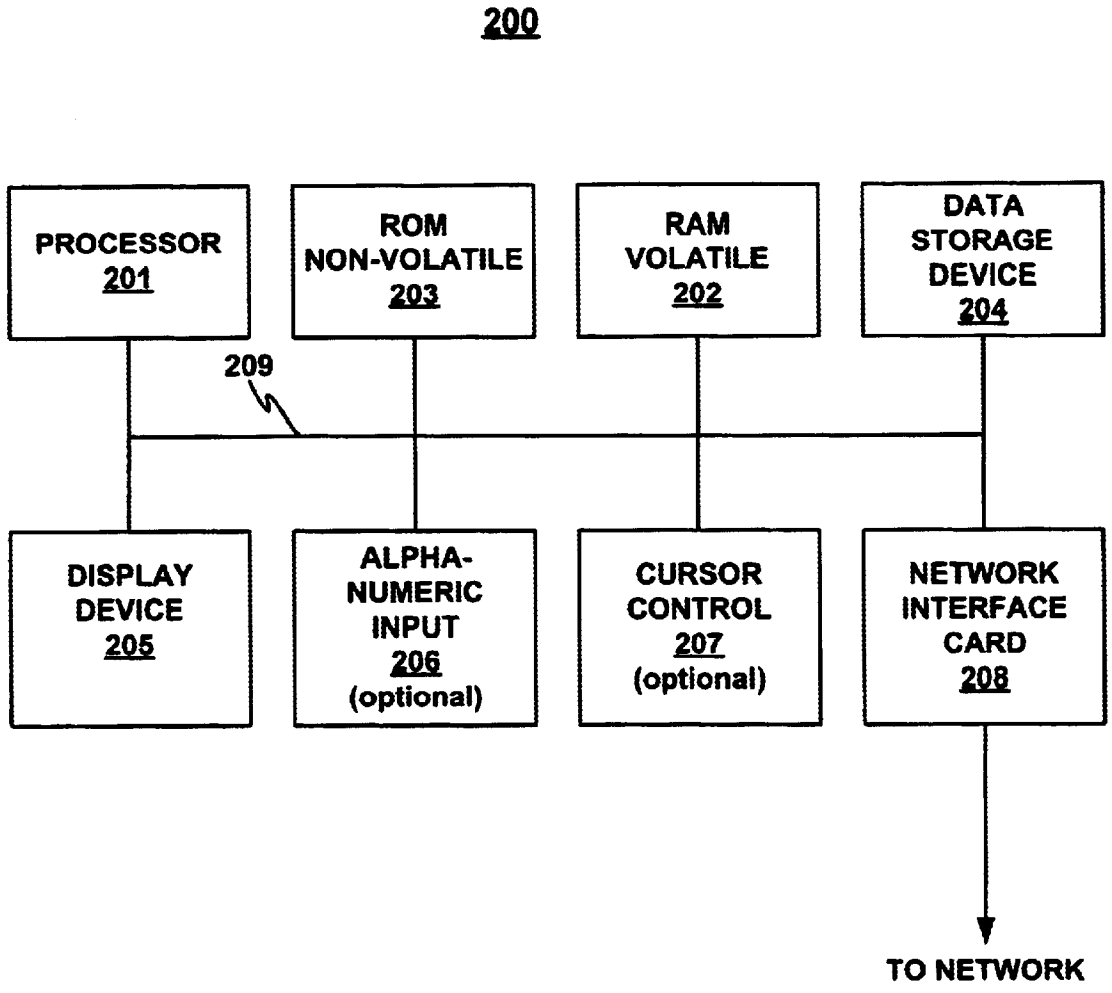

200
PROCESSOR
201
ROM
NON-VOLATILE
203
RAM
VOLATILE
202
DATA
STORAGE
DEVICE
204
209
DISPLAY
DEVICE
205
ALPHA-
NUMERIC
INPUT
206
(optional)
CURSOR
CONTROL
207
(optional)
NETWORK
INTERFACE
CARD
208
TO NETWORK

FIG. 2

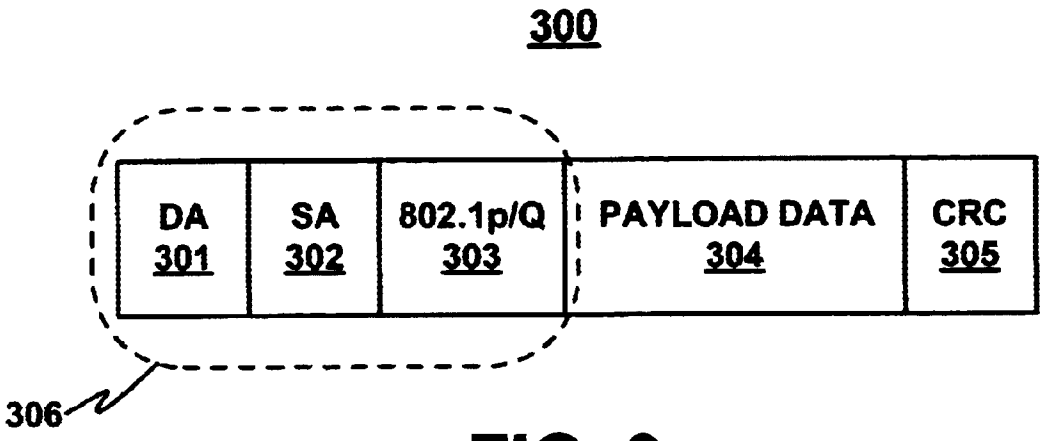


FIG. 3

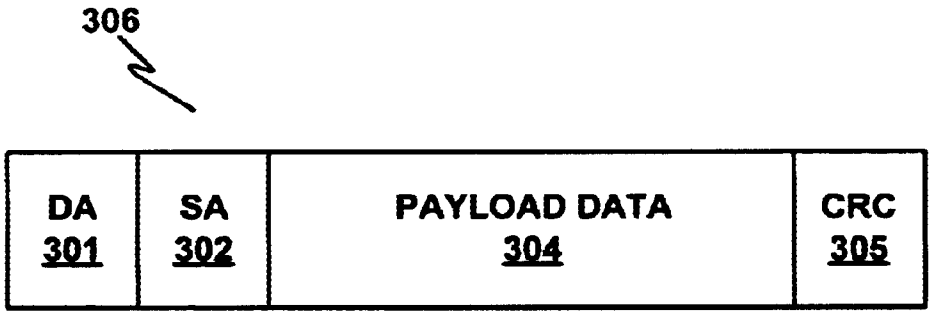


FIG. 3A

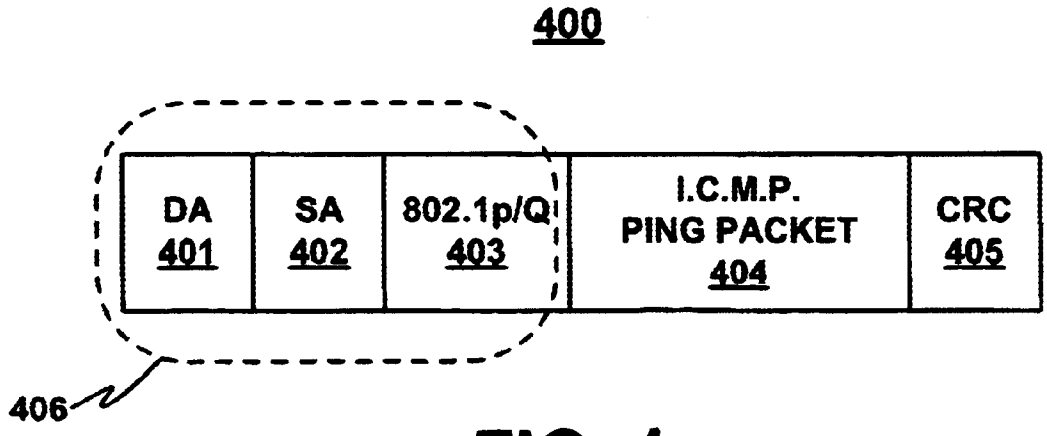


FIG. 4

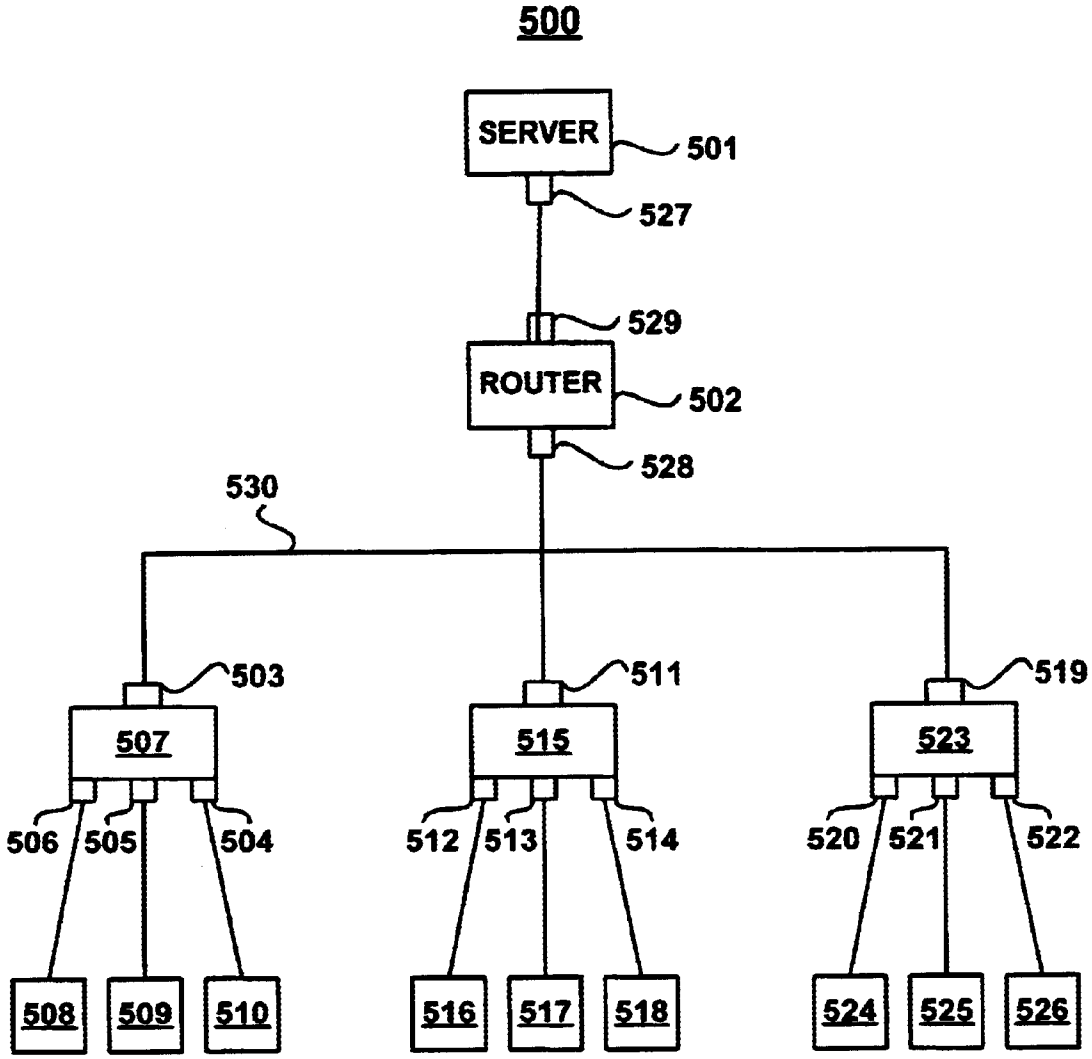

500
SERVER
501
527
529
ROUTER
502
528
530
503
511
519
507
515
523
506
505
504
512
513
514
520
521
522
508
509
510
516
517
518
524
525
526

FIG. 5

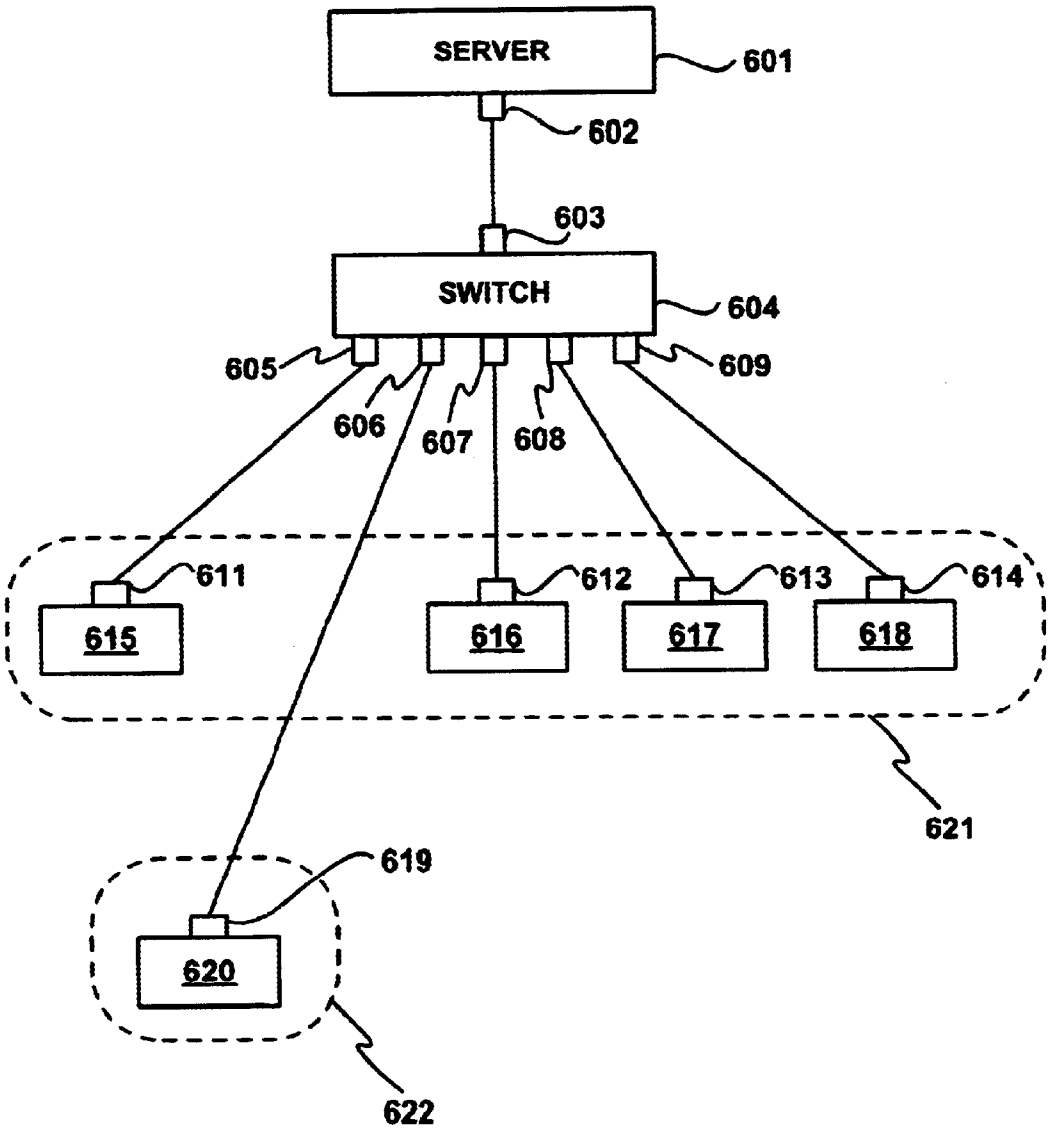

SERVER
601
602
603
SWITCH
604
605
606
607
608
609
611
612
613
614
615
616
617
618
621
619
620
622

FIG. 6

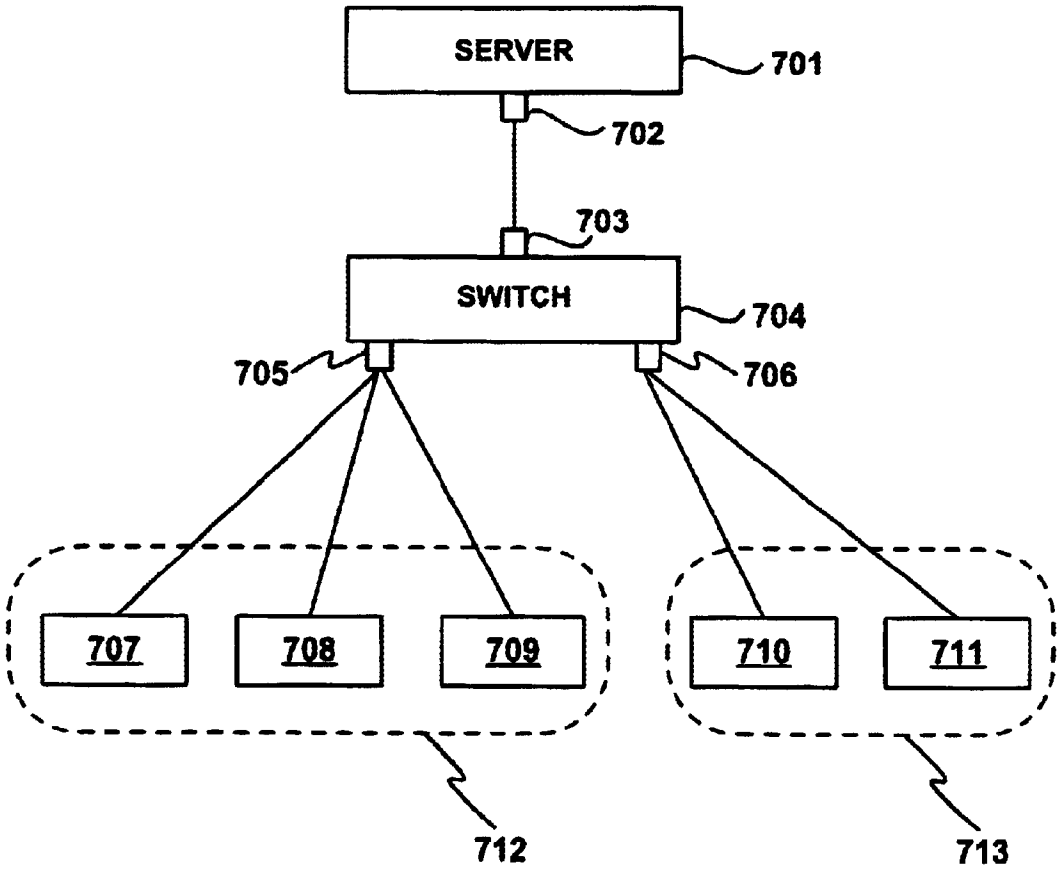

SERVER
701
702
703
SWITCH
704
705
706
707
708
709
710
711
712
713

FIG. 7

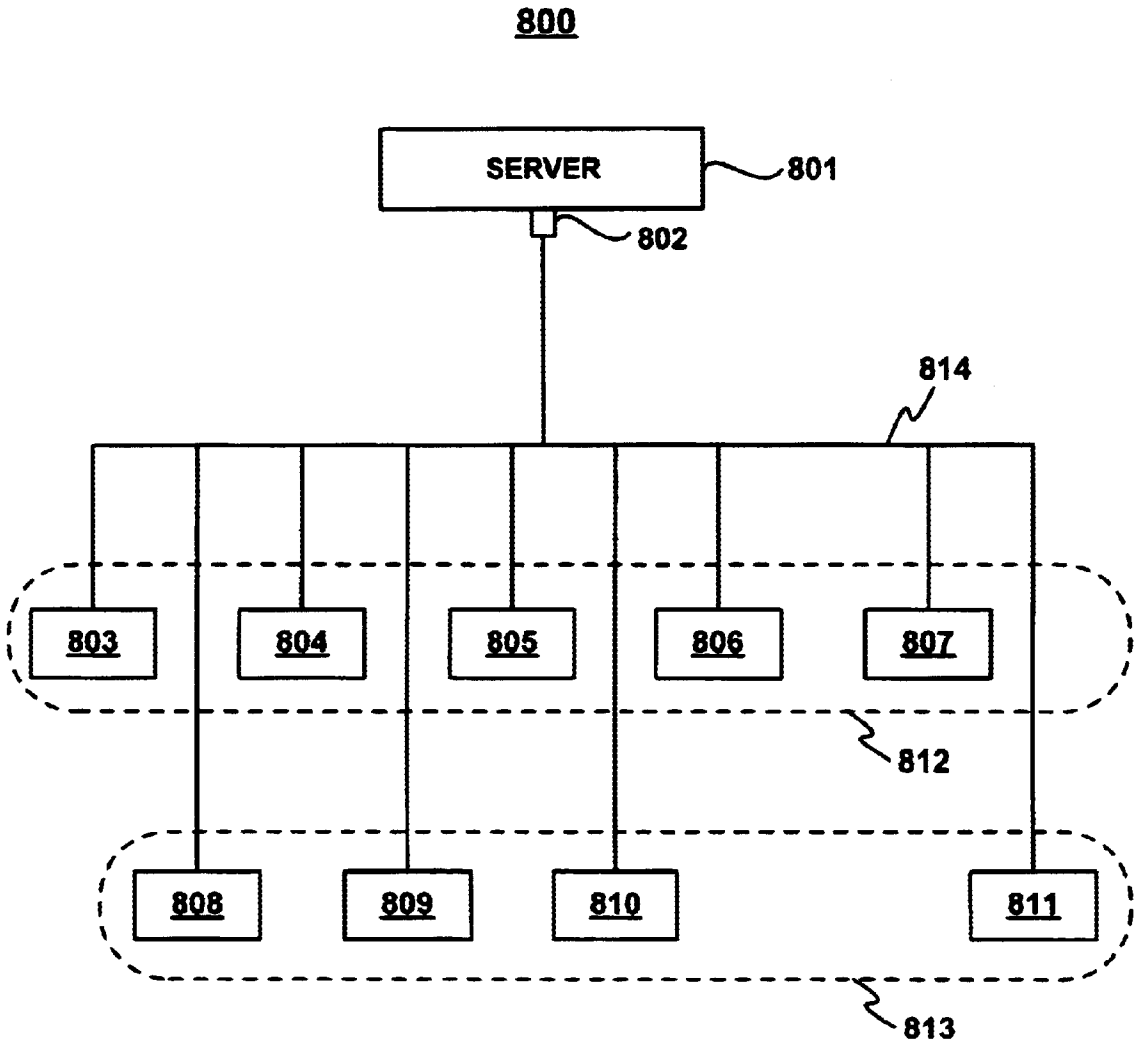

800
SERVER
801
802
814
803
804
805
806
807
812
808
809
810
811
813

FIG. 8

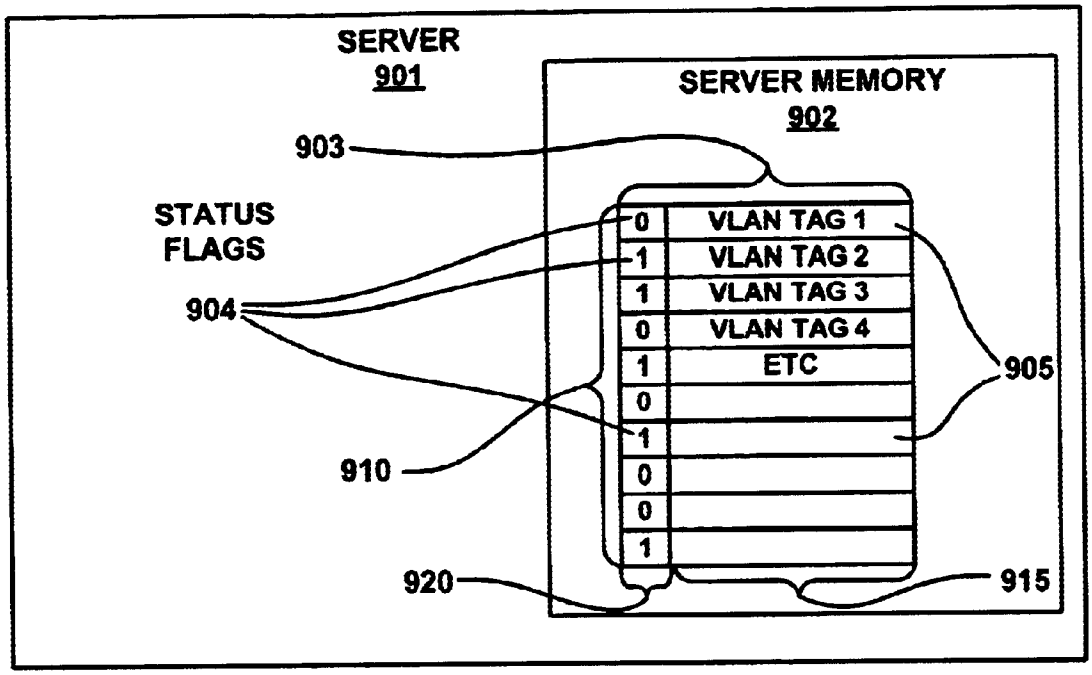

SERVER
901
SERVER MEMORY
902
903
STATUS
FLAGS
904
910
920
905
915
0 VLAN TAG 1
1 VLAN TAG 2
1 VLAN TAG 3
0 VLAN TAG 4
1 ETC
0
1
0
0
1

FIG. 9

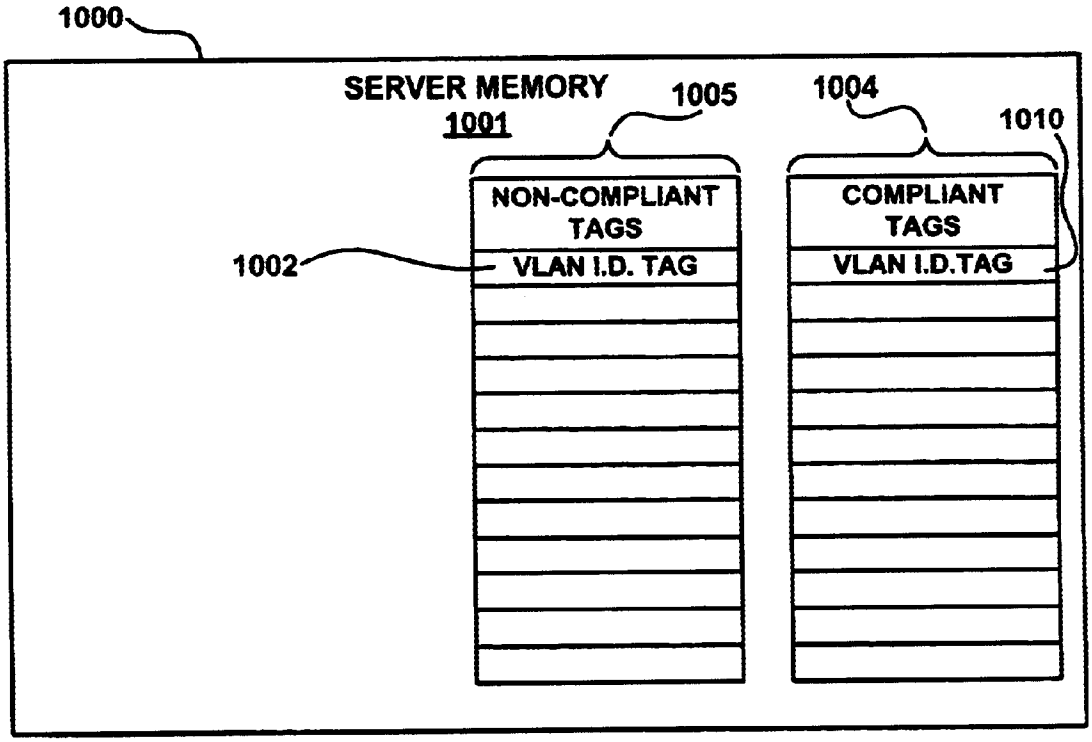

1000
SERVER MEMORY
1001
1005
1004
1010
1002
NON-COMPLIANT TAGS
VLAN I.D. TAG
COMPLIANT TAGS
VLAN I.D.TAG

FIG. 10

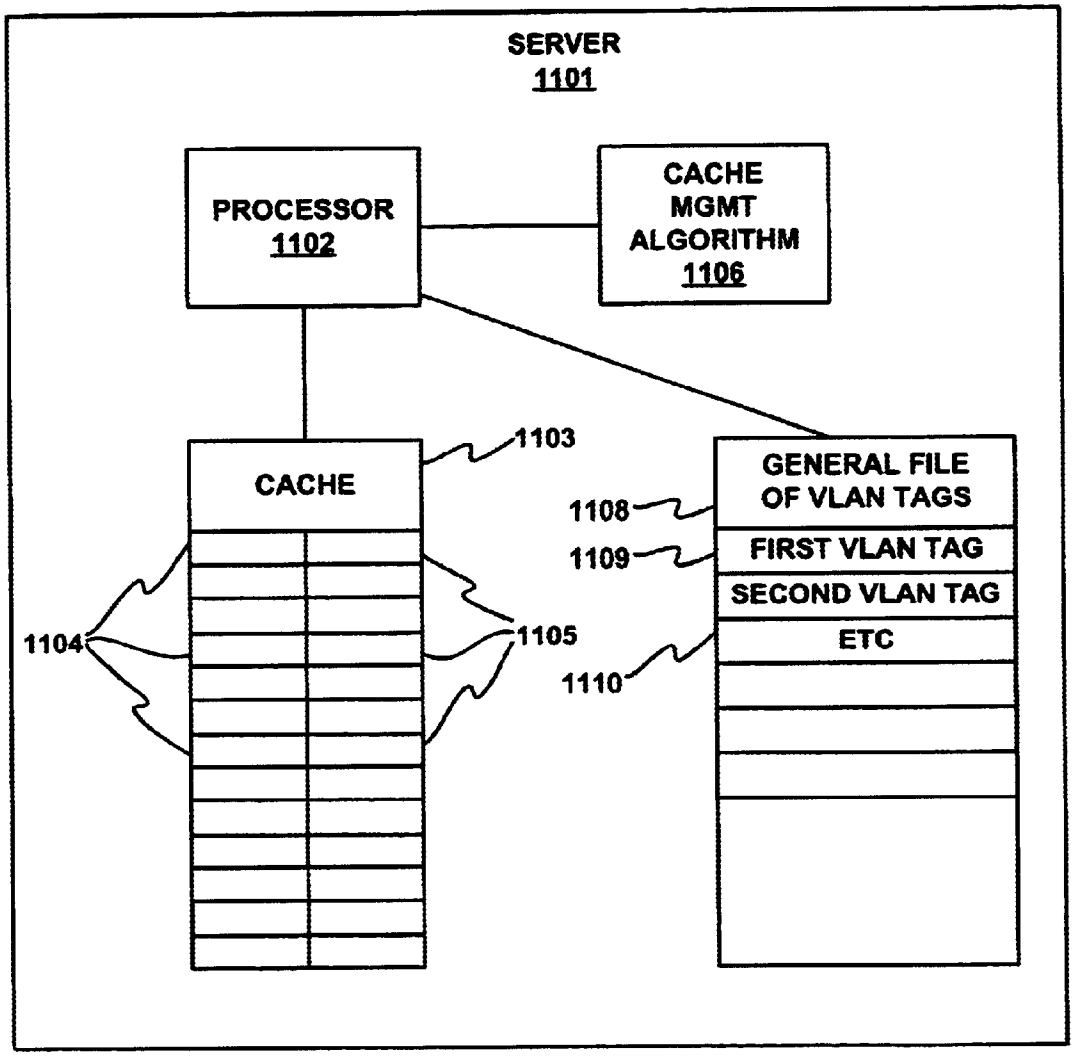

SERVER
1101
PROCESSOR
1102
CACHE
MGMT
ALGORITHM
1106
CACHE
1103
1104
1105
GENERAL FILE
OF VLAN TAGS
1108
1109
FIRST VLAN TAG
SECOND VLAN TAG
ETC
1110

FIG. 11

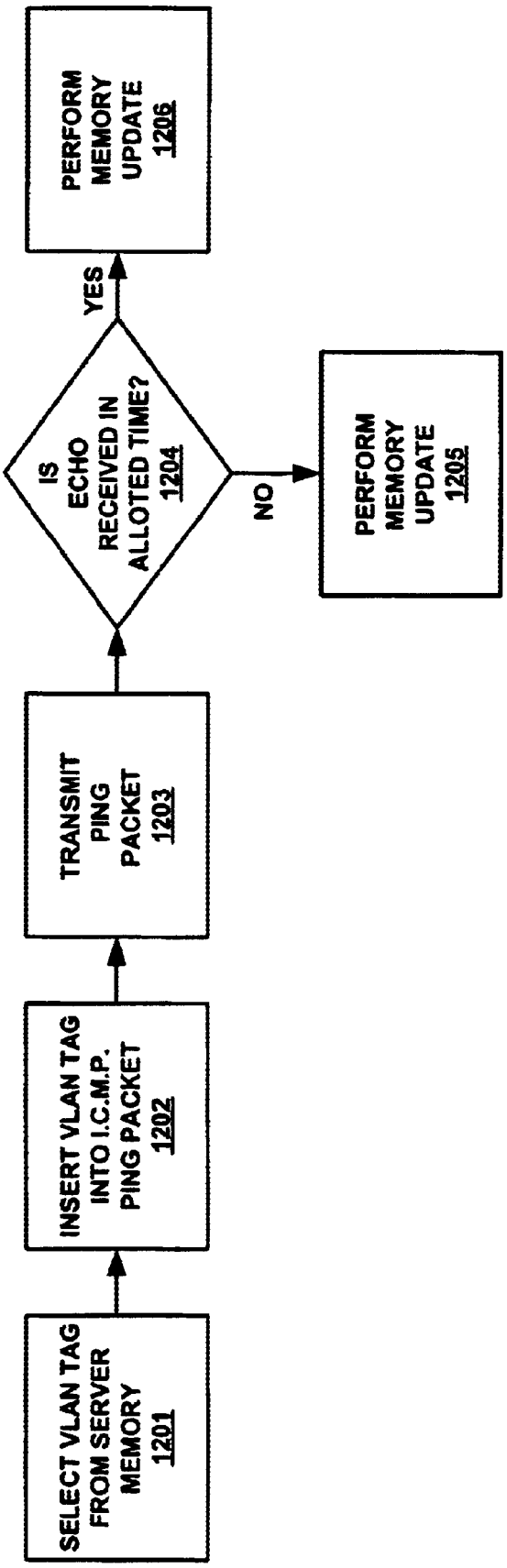

SELECT VLAN TAG FROM SERVER MEMORY 1201
INSERT VLAN TAG INTO I.C.M.P. PING PACKET 1202
TRANSMIT PING PACKET 1203
IS ECHO RECEIVED IN ALLOTED TIME? 1204
NO
PERFORM MEMORY UPDATE 1205
YES
PERFORM MEMORY UPDATE 1206

FIG. 12

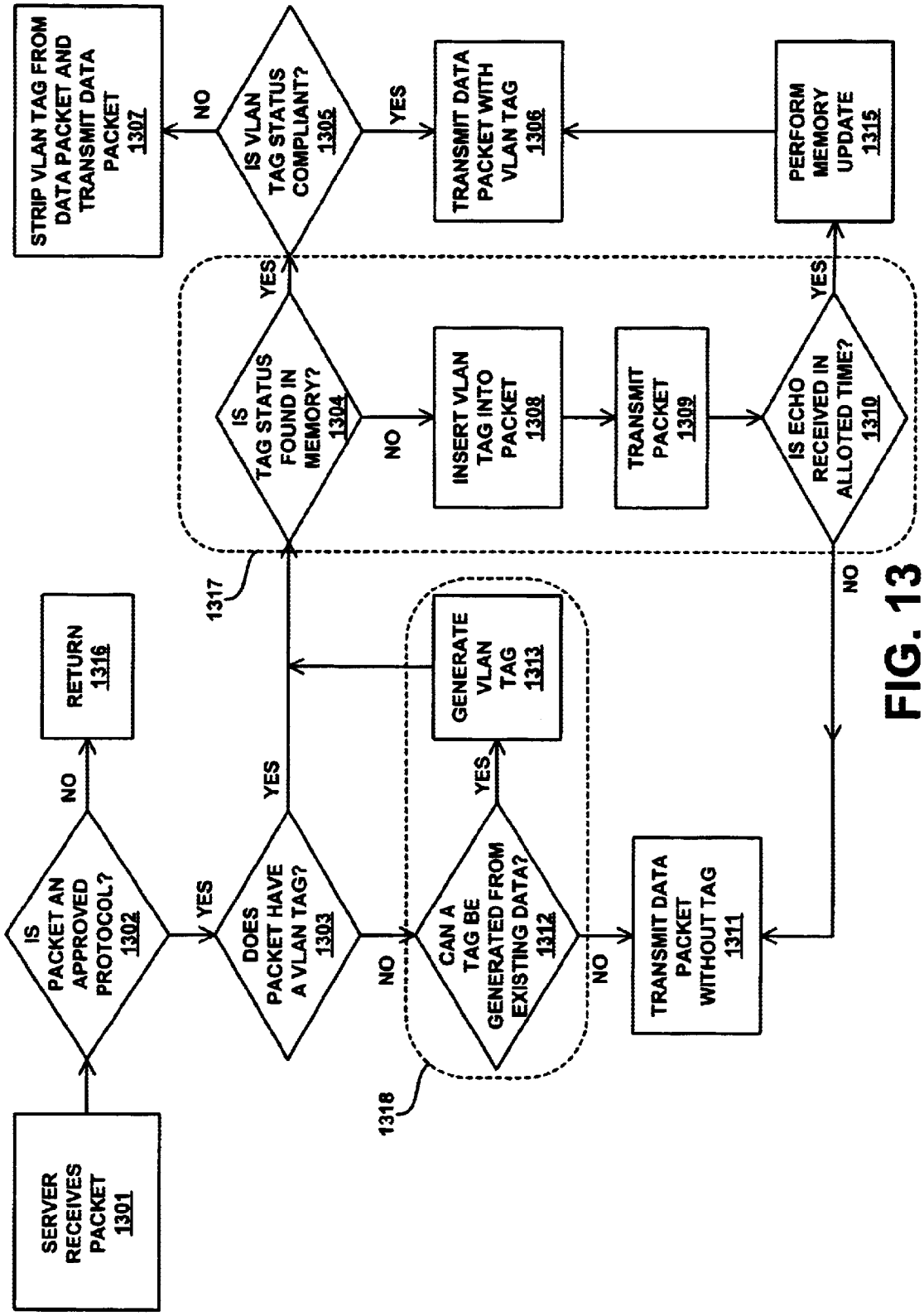

SERVER RECEIVES PACKET 1301
IS PACKET AN APPROVED PROTOCOL? 1302
NO
YES
RETURN 1316
DOES PACKET HAVE A VLAN TAG? 1303
YES
NO
CAN A TAG BE GENERATED FROM EXISTING DATA? 1312
YES
NO
GENERATE VLAN TAG 1313
TRANSMIT DATA PACKET WITHOUT TAG 1311
1317
1318
IS TAG STATUS FOUND IN MEMORY? 1304
YES
NO
INSERT VLAN TAG INTO PACKET 1308
TRANSMIT PACKET 1309
IS ECHO RECEIVED IN ALLOTED TIME? 1310
YES
NO
PERFORM MEMORY UPDATE 1315
IS VLAN TAG STATUS COMPLIANT? 1305
NO
YES
STRIP VLAN TAG FROM DATA PACKET AND TRANSMIT DATA PACKET 1307
TRANSMIT DATA PACKET WITH VLAN TAG 1306

FIG. 13

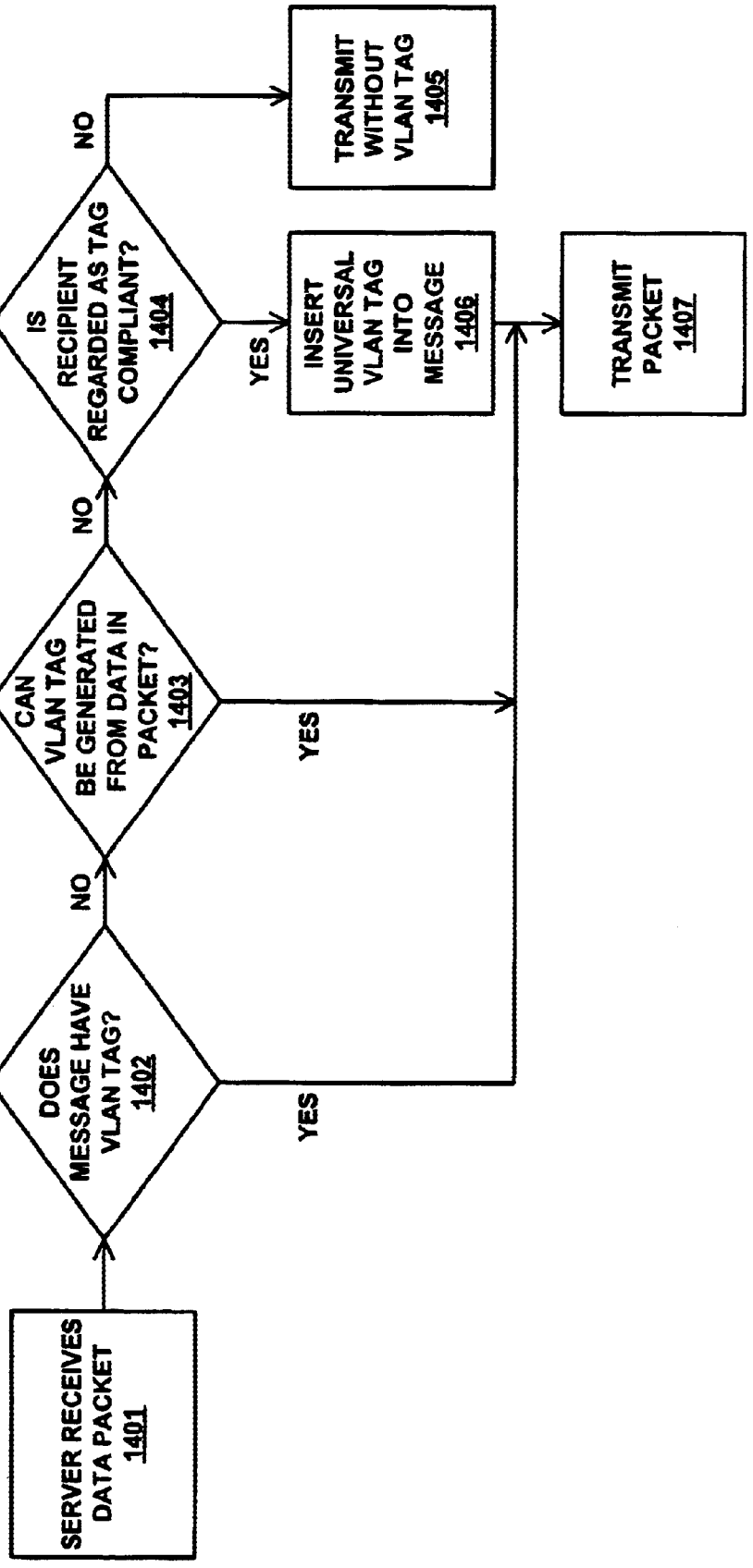

SERVER RECEIVES DATA PACKET 1401
DOES MESSAGE HAVE VLAN TAG? 1402
NO
YES
CAN VLAN TAG BE GENERATED FROM DATA IN PACKET? 1403
NO
YES
IS RECIPIENT REGARDED AS TAG COMPLIANT? 1404
NO
YES
TRANSMIT WITHOUT VLAN TAG 1405
INSERT UNIVERSAL VLAN TAG INTO MESSAGE 1406
TRANSMIT PACKET 1407

FIG. 14

TAG ECHO DISCOVERY PROTOCOL TO DETECT REACHABILITY OF CLIENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of computer system networks. In particular, the present invention pertains determining the current status and reachability of a specific client computer.

2. Description of the Related Art

The increasing levels of communication taking place between computers has given rise to increasing need for specialized networks that can insure inexpensive and timely transmission of data. A LAN (Local Area Network) is a group of computers connected by a common communication network. One of the goals of the earlier LANs was to avoid transmission using the Public Switched Telephone Network, (PSTN) which could result in undue delays, as well as ongoing costs which are avoidable through a LAN. With increasing sophistication of digital electronics, LANs can be segregated into sub-nets called virtual LANs (VLANs). A sub net is a select group of computers on a net that have some common object, goal or function which distinguishes them from other network computers.

The operation and utility of a VLAN can be illustrated by an example of a modern hospital, where computers are interconnected for communication. VLANs would further break down the hospital into smaller units. Patient health records, accounts receivable, disbursing, employee health benefits, pathology, neurology and ophthalmology each have separate concerns. Some memoranda, such as an upcoming Christmas party, might be relevant to all hospital employees. Other memoranda might be relevant only to those persons in accounts receivable. If all memoranda generated within the hospital were forwarded to all hospital personnel at all times, the time to read the memoranda could consume every working minute of every employee. Physicians would be so inundated with irrelevant memos that the healing of the sick would grind to a halt.

Virtual LANs provided a major step in solving this problem. Even though all computers in this hospital are on the same communication network, by using distinct VLAN identifier tags typically placed in the header of a message, only those computers capable of recognizing that particular identifier tag would process the memo. Accounts receivable would have its own identifier tag, as would disbursing, ophthalmology, the pathology lab, and every other department. The practical implementation of VLANs has proven somewhat problematic however.

The first problem is that many computer networks are heterogeneous, comprising both "compliant" client computers (able to read VLAN identifier tags), and "non-compliant" computers, which cannot recognize a message header containing the bit field required for a VLAN tag. If a message with a VLAN identifier tag is sent to a non-compliant computer, the message is simply ignored.

One solution to this problem has been the use of electronically configurable switches. To accommodate computers which are non-compliant, an individual port on a configurable switch can be configured to strip out any VLAN identifier tag. The message header is thereby reformatted to a form that is recognizable by a non-compliant computer.

A "stack network" using such configurable switches however creates its own set of problems. If a user were to unplug a computer from its normal communication port on the LAN, and plug in to a communication port one desk away, the two ports may be routed into different ports on the configurable switches leading to the server computer. One port may be configured for compliant computers, and the other for non-compliant computers. By simply changing port connections, a client computer can thereby degrade its ability to communicate on the LAN.

A similar problem would be upgrading a client from non-compliant status to compliant status. Just as the bit field of a VLAN identifier tag renders the packet header unrecognizable to a legacy (non-compliant) computer, a compliant computer can not use VLAN identifier when communicating with a legacy computer.

Another problem with "stack networks" is their ability to segregate a network. Even if two "intelligent" switch ports are configured for compliant computers, they may each be dedicated to different VLAN identifier tags. If there were ten separate VLANs on the LAN, port **1** may limit its transmissions to messages with VLAN identifier **#1**, and strip out all other transmissions. Port **2** may similarly limit transmissions to messages with VLAN identifier tag **#2**. Accordingly, if someone were to take a computer to another location on the LAN, even if both locations were compliant, the client computer might be unable to receive transmissions in its new location.

Transmissions also go from a client to a server. If a heterogeneous mix of compliant and non-compliant clients were communicating to a server, the transmissions in a stack network would again go through configurable switches. To insure that all messages reach the server with the same size bit field in the header, a switch-port serving a non-compliant computer can be configured to insert a "universal VLAN tag" (a bit field the same size as a normal VLAN identifier tag) into the proper location in the message header, thereby enabling the server to receive and respond to the transmission. While solving one problem however, this process again creates another problem. If a switch port were configured to communicate with a legacy (non-compliant) client, and an upgraded (compliant) computer were to connect to that port, the client would now be sending a message with a VLAN identifier tag in the header.

One solution has been to employ a Management Information Specialist (MIS) to maintain a LAN. Switches and routers are continually reconfigured by the MIS to reflect the dynamics of VLAN usage. If a client computer at a given port is upgraded from non-compliant to compliant, the outlet ports on the switches are reconfigured by the MIS. Once again, however, a solution becomes a problem. Networks may have a thousand or more computers. A large network may require an entire staff of Management Information Specialists to maintain a network. This obviously increases operational costs of a company. Moreover, even the most efficient maintenance staff is unlikely to be able to reconfigure the network in such a timely manner that no transmissions are ever dropped. Any lag time in reconfiguration can result in lost transmissions.

Finally, with or without a stack-network of configurable switches, one problem remains wholly unresolved. When a message is rejected by a client, the server has no way of knowing that a message has gone undelivered. Therefore, the server will make no effort to re-send the message in a more readable format.

A need therefore exists for a method and apparatus for allowing a server to communicate to client computers on a heterogeneous network of compliant and non-compliant

computers. A further need exists for a method and apparatus that will allow efficient communication on a dynamic network where compliant and non-compliant computers may be interchanged at various network communication ports. A further need exists for a method and apparatus of determining whether a client computer is compliant or non-compliant before attempting to transmit data to that client computer. A further need exists for determining with a high probability whether transmission from a server to a client was successfully executed. A further need exists for a method and apparatus that will respond to dynamic changes in the status of client computers by reconfiguring itself without the need of a costly maintenance staff. A further need exists for a method and apparatus that will respond to dynamic changes in the status of client computers by reconfiguring itself in-or-near real time, thereby avoiding the failed communications that necessarily attend a lengthy or delayed reconfiguration. A further need exists for portability in a network communications system, wherein computers can be moved to different ports of a network without degrading the communication ability of that network.

SUMMARY OF THE INVENTION

The present invention provides a system and method allowing a server to communicate to client computers on a heterogeneous network of compliant and non-compliant computers. The present invention further provides a method and apparatus that will allow efficient communication on a dynamic network where compliant and non-compliant computers may be interchanged at various network communication ports. The present invention further provides a system and method for determining whether a client computer is compliant or non-compliant before attempting to transmit data to that client computer. The present invention further provides a system and method for determining with a high probability whether transmission from a server to a client was successfully executed. The present invention further provides a system and method for a server to respond to dynamic changes in the status of client computers by reconfiguring itself without the need of a costly maintenance staff. The present invention further provides a system and method that will respond to dynamic changes in the status of client computers by reconfiguring itself in-or-near real time, thereby avoiding the failed communications that necessarily attend a lengthy or delayed reconfiguration. The present invention further provides a system and method for portability in a network communications system, wherein computers can be moved to different ports of a network without degrading the communication ability of that network.

According to one embodiment of the present invention, the reachability of client computers communicatively coupled in a computer network to a server computer is determined. The server uses an I.C.M.P. "ping" in place of the data payload of a normal message, and then inserts a VLAN identifier tag into the proper data segment of the header of the packet. This tagged packet is transmitted on a network to determine if a client corresponding to that identifier tag is present on the network and able to read the identifier tag. A client computer that cannot recognize a message header containing a VLAN tag will simply ignore the message. Therefore, if the client computer transmits a ping response within a predetermined period of time, the client is known to be compliant with the identifier tags, and the server memory is updated to reflect the "compliant" status of the client computer. If no responsive echo is received after a predetermined time period, the client is known to be non-compliant. The server memory contains a plurality of identifier tags along with their last known status. If, as a result of the tagged ping-packet transmission the results of the client status are determined to have changed, the memory is updated accordingly.

These and other objects and advantages of the present invention will become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiments which are illustrated in the various drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a general purpose server computer system upon which embodiments of the present invention may be implemented in accordance with one embodiment of the present claimed invention.

FIG. **2** depicts a general purpose client computer system upon which embodiments of the present invention may be implemented in accordance with one embodiment of the present claimed invention.

FIG. **3** depicts a digital VLAN data packet containing payload data implemented in accordance with one embodiment of the present claimed invention.

FIG. **3A** depicts the data packet of FIG. **3**, but lacking the VLAN tag in accordance with one embodiment of the present claimed invention.

FIG. **4** depicts a digital VLAN data packet containing an I.C.M.P. ping packet in place of the normal data payload in accordance with one embodiment of the present claimed invention.

FIG. **5** depicts a stack network configuration with a single server and multiple clients implemented in accordance with one embodiment of the present claimed invention.

FIG. **6** depicts a stack network, pre-configured for compliant and non-compliant clients implemented in accordance with one embodiment of the present claimed invention.

FIG. **7** depicts a stack network with switch communication ports limited to homogenous users.

FIG. **8** depicts a parallel network configuration as might be utilized with the present invention, wherein the same communication port may be used to transmit to compliant and non-compliant clients implemented in accordance with one embodiment of the present claimed invention.

FIG. **9** depicts one embodiment of a memory structure and organization according to the present invention, wherein flags within the memory are used to record status of an identifier tag in accordance with one embodiment of the present claimed invention.

FIG. **10** depicts one embodiment of a memory structure and organization as envisioned with the present invention, wherein identifier tags are segregated into separate files, variously designated as compliant and non-compliant in accordance with one embodiment of the present claimed invention.

FIG. **11** depicts one embodiment of a memory structure and organization as envisioned with the present invention wherein priority identifier tags and their respective attributes are stored in a cache type memory, and non-priority tags are stored in a more general area of memory implemented in accordance with one embodiment of the present claimed invention.

FIG. **12** depicts a flow chart of a dynamic (ongoing) ping-echo memory update of client status implemented in accordance with one embodiment of the present claimed invention.

FIG. **13** depicts a flow chart wherein client status is determined upon receipt of a data packet in accordance with one embodiment of the present claimed invention.

FIG. **14** depicts a flow chart for inserting a universal VLAN tag into data packets implemented in accordance with one embodiment of the present claimed invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made to the preferred embodiment of the invention, a tag echo discovery system using VLAN identifier tags, examples of which are illustrated in the accompanying drawings. While the invention will be described in conjunction with the preferred embodiments, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are frequently set forth in order to conceptually illustrate the workings of the present invention. However, it will be obvious to one ordinarily skilled in the art that the present invention may be practiced without these specific details. In other instances, well known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the current invention.

Some portions of the detailed descriptions which follow are presented in terms of procedures, logic blocks, and other symbolic representations of operations on data bits within a computer memory. These descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. A procedure, logic block, process, etc., is here, and generally, conceived to be a self-consistent sequence of steps or instructions leading to a desired result. These steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, bytes, values, elements symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the following discussions, it is appreciated that throughout the present invention, discussions utilizing terms such as "selecting" or "associating" or "storing" or "reading" or "sending" or "initiating" or "replacing" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The present invention pertains to a method and apparatus for determining the reachability and status of client computers in a heterogeneous network comprising tag-compliant and tag-non-compliant client computers. Although the present invention is discussed largely in the context of VLAN, 802.1 p/Q identifier tags, and I.C.M.P. ping packets, it is understood that other protocols, identifier tags, or ping-echo technology, as exist now or as developed in the future, may be utilized in accordance with the present invention.

FIG. **1** discloses an exemplary server computer system **100** upon which embodiments of the present invention may be practiced. The server computer system **100** is communicatively coupled to other computer systems (not shown) in a network through a network interface card **108**.

In general, server computer system **100** used by the embodiments of the present invention comprises a central processor **101** for processing information and instructions, a random access memory **102** for storing information and instructions for central processor **101**, a read only memory **103** for storing static information and instructions for central processor **101**, a data storage device **104** such as a magnetic or optical disk and disk drive for storing information and instructions, an optional display device **105** for displaying information to the computer user, an optional alphanumeric input device **106** including alphanumeric and function keys for inputting information and command selections to the central processor **101**, an optional cursor control device **107** for inputting user input information and command selections to the central processor **101**, a network interface card **108** for transmitting and receiving from the central processor **101** to the network (not shown), and a bus **109** communicatively connecting the central processor **101**, the random access memory **102**, the read only memory **103**, the data storage device **104**, the optional display device **105**, the optional alpha numeric input **106**, the optional cursor control **107**, and the network interface card **108**.

Display device **105** of FIG. **1** utilized with the server computer system **100** of the present embodiment may be a liquid crystal device, cathode ray tube, or other display device suitable for creating graphic images and alphanumeric characters recognizable for the user. Cursor control device **107** allows the computer user to dynamically signal the two-dimensional movement of a visible symbol (pointer) on a display screen of display device **105**. Many implementations of the cursor control device are known in the art including a trackball, mouse, joystick or special keys on alphanumeric input device **106** capable of signaling movement of a given direction or manner of displacement. It is to be appreciated that the cursor control device **107** also may be directed and/or activated via input from the keyboard using special keys and key sequence commands. Alternatively, the cursor may be directed and/or activated via input from a number of specially adapted cursor detecting devices.

FIG. **2** discloses a general purpose client computer system **200** upon which embodiments of the present invention may be implemented. Client computer system **200** is communicatively coupled to the server computer **100** shown in FIG. **1** by means of network interface card **208** that connects the client computer to the network (not shown). In general, processor **201**, random access memory **202**, read only memory **203**, data storage device **204**, optional display device **205**, optional alphanumeric input device **206**, optional cursor control device **207**, and bus **209** function and interact as described in conjunction with FIG. **1**. Although computer systems **100** and **200** are shown having network interface cards **108** and **208**, respectively, the present invention is also well suited to an embodiment in which computer systems **100** and **200** are coupled to the network or each other using means other than a network interface card.

FIG. **3** depicts one embodiment of a digital data packet containing a data payload. The data packet **300** can represent

a bit sequence stored in memory, or a bit stream being transmitted. Destination address "DA" **301** contains a bit sequence representing a computer or station being targeted to receive the data packet **300**. Source address SA **302** contains a bit sequence representing the address of the computer from which the data packet originated.

The optional 802.1 p/Q "VLAN identifier tag" **303** is a four-byte field comprising a fixed Ethertype VLAN identification number and a "Quality of Service" or QoS number. The VLAN I.D. defines a particular virtual LAN to which the source is communicating, and only computers configured to recognize that VLAN I.D. number will receive the message. The QoS number determines that, if a variety of messages are in a queue, rather than transmitting the messages in a "first in, first out" manner, a computer will prioritize the messages according the their QoS number, thereby insuring that the most time critical messages are transmitted first. Together, the destination address **301**, the source address **302** and the VLAN tag **303** comprise at least a portion of the message "header" **306**.

For purposes of the present application, "compliant" computers are those computers on a VLAN that are configured to recognize a particular 802.1 p/Q bit sequence. When a data packet **300** comprising a VLAN identifier tag **303** is transmitted to a compliant computer, the message will be received and processed. However, when a data packet **300** comprising a VLAN identifier tag **303** is transmitted to a non-compliant computer, the message will be ignored or "dropped." Similarly, if transmitted to another compliant computer that has not been configured to recognize that particular VLAN tag, the message will again be ignored.

The payload data **304** comprises the actual file or data being transmitted. It could be a memorandum, spread sheet, digital photograph, or any other data pattern that the source has chosen to transmit.

The cyclical redundancy check CRC **305** is an error checking technique to insure that data has not been not corrupted in transmission. A computer transmitting the data will take the bit stream being transmitted and perform a mathematical reduction upon the bit pattern of the message. The mathematical algorithm is typically chosen such that a small one-bit difference in the payload data will produce a radically different bit pattern when mathematically reduced, such as polynomial division. The resultant number is the bit pattern forming the CRC **305**, which typically is transmitted as a tail on the data packet. When the transmission is received, the receiving computer reduces the bit stream according to the identical algorithm, generating a comparison number. The receiving computer then compares the comparison number to the CRC **305** received within the data packet **300**. If the numbers are identical, there is a strong likelihood that the transmission was uncorrupted. If the numbers are different, the transmission was corrupted, and the message is discarded.

FIG. **4** depicts a digital VLAN ping/echo packet **400** comprising an 802.1 p/Q VLAN identifier tag **403** and an I.C.M.P. ping packet **404** structure in accordance with one embodiment of the present invention. A brief overview of the processes of the present invention is recited below. This brief overview is followed by a detailed description of the operation of the present invention. The destination address **401**, source address **402**, VLAN 802.1 p/Q identifier tag **403**, and CRC **405** function the same as in FIG. **3**. In the present embodiment, when the VLAN ping/echo packet **400** disclosed in FIG. **4** is transmitted to a compliant computer **200** configured to recognize the 802.1 p/Q VLAN identifier tag **403**, the client **200** will receive and process the packet. I.C.M.P. ping packet **404** is a program command that initiates an echo response from the receiving computer. When the client computer **200** therefore generates a responsive data packet and transmits within a predetermined time frame, the server **100** will receive the transmission and knows that the client assigned to that VLAN identifier tag is compliant.

Furthermore, in the present embodiment, if the client computer is unable to recognize the VLAN tag, it will simply ignore the packet. Therefore, if a server **100** transmits the VLAN ping/echo packet **400** disclosed in FIG. **4** and no echo response is received in the allotted time, the server computer **100** determines that the client assigned that VLAN I.D. is non-compliant. In one embodiment, the ping is retransmitted a few times to make certain that the client is receiving and ignoring the ping.

FIG. **5** discloses a stack network configuration **500** utilized in accordance with one embodiment of the present invention. A single server **501** transmits through a communication port **527** to a network. Any number of intermediary routers **502** comprising an inlet and an outlet port **528**, **529** may be disposed between the server **501** and the network switches **507**, **515** and **523**. From outlet port **528**, the router **501** relays signals from the server **501** along the network communication path **530** to the inlet ports **503**, **511**, **519** on network switches **507**, **515**, **532**. The outlet ports **504**, **505**, **506**, **516**, **517**, **518**, **524**, **525** and **526** on the network switches **507**, **515** and **523** are individually configurable. An outlet port may therefore be configured to communicate with compliant or non-compliant client computers.

Referring now to FIG. **6**, a stack network **600** is displayed comprising a compliant network portion **621**, and a non compliant portion **622**. To facilitate communication between server **601** and client **620**, communication port **606** would be configured to strip out the 802.1 p/Q VLAN identifier tag **303** from any message being transmitted to client computer **620**. A message would be reduced from the packet depicted in FIG. **3** to the packet depicted in FIG. **3**-a. Similarly, when signals are sent from client **620** back to server **601**, they would lack a VLAN identifier tag **303**. If the server were unable to recognize a packet header lacking this bit field, communication port **606** on switch **604** could be configured to insert a 4 byte field in the header where a VLAN identifier tag would normally be found, thereby allowing the signal to reach the server in a format expected by the server.

Alternatively, if client computer **615** were known to be compliant, communication port **605** on switch **604** would be configured to allow the entire packet **300** to pass through the port to the client. A data packet **300** would thereby reach client **615** with the VLAN identifier tag intact.

Referring now to FIG. **7**, a stack network **700** controlled by a configurable switch **704** is seen to be controlling transmissions to a compliant portion of the network **712** and a non compliant portion of the network, **713**. In a portable environment where laptop computers are moved around, if client **710** were moved to another port which connected to communication port **705** of switch **704**, communication between server **701** and client **710** would cease. Similarly, if compliant client computer **707** were plugged into a communication port leading to port **706** on switch **704**, communication would similarly break down. Finally, if client **710** were upgraded from non-compliant status to compliant status, it would have to be moved to communication port **705**. Similarly, if a new computer were purchased to replace client computer **707**, and the new computer had not been

configured to recognize VLAN tags, the new computer would be unable to communicate on the network through the same port as the original computer **707**. This becomes even more problematic when an alternative communication port is not a convenient distance from client computers **707** or **710**.

FIG. **8** displays a heterogeneous parallel network configuration **800** which could be used advantageously in conjunction with the present invention. A server **801** communicates through communication channel **814** to a network of both compliant computers **812** and non-compliant computers **813**. Through employing the invention disclosed herein, no switches or ports need be configured to accommodate individual computers. One obvious benefit of such a network configuration is the elimination of a maintenance staff needed to configure switches and routers comprising a dynamic stack type network. A second benefit is the portability of all computers. A computer may be moved to another port, or a new computer purchased and installed anywhere on the network and still function without being reconfigured.

FIG. **9** discloses a memory structure **902** of a server computer **901** according to one embodiment of the present invention. Within the server memory **902** is a reachability file **903** comprising a plurality of records **910**. Each record **910** comprises a first field **915** containing one of a plurality of VLAN identifier tags **905**, which may or may not be active on the net. Each record **910** further comprises a second field **920** containing a status flags **904**, which reflects the status of the client computer corresponding to a given VLAN identifier tag **905**. When a VLAN ping/echo packet determines the status of a client computer, the status flag **904** corresponding to the VLAN identifier tag **905** of that computer is examined, and its status is updated in the reachability file **903**. The first field **920** (e.g., status flags **904**) may contain as little as one bit per flag, which would be sufficient to reflect the compliant/non-compliant status of a client computer. If the status of the client computers is updated frequently enough to be regarded as reliable, the server **902** preparing to transmit a packet to a client computer need not "ping" the client computer to determine the status. The server **901** need simply check the status **904** of a particular client computer in the reachability file **903** maintained in the server's memory **902**.

Referring now to FIG. **10**, an alternative embodiment of the present invention comprises a memory structure **1001** comprising two separate reachability files **1004**, **1005**. A first of the reachability files **1004** comprises a plurality of records of compliant VLAN identifier tags **1010**. A second of the reachability files **1005** comprises a plurality of records of non-compliant VLAN identifier tags **1002**. As clients are "pinged" and status changes, respective VLAN identifier tags **1010**, **1002** are moved from one reachability file **1004**, **1005** to the other. Before transmitting a message, a server **100** need only search the first reachability files **1004** containing a list of compliant VLAN identifiers **1010**. If a VLAN identifier tag **1010** is not found in the first reachability file **1004**, it is necessarily non-compliant or not presently on the network. Because the second reachability file **1005** need not be searched, a two-file system can reduce execution time when performing a status check.

Referring now to FIG. **11**, one embodiment of the memory structure and organization as envisioned with the present invention comprises a cache type memory **1103**. A "cache" typically refers to an area of memory that can be more quickly accessed by the microprocessor than other areas of memory. Some microprocessors have a cache memory integral to the microprocessor. Within a random access memory, data stored in a "higher" area of memory are more quickly accessed by a microprocessor. The use of the term "cache" **1103** herein is not intended to be limited to any one embodiment of cache memory, but rather, comprises to any type or area of memory, existing or to be developed in the future, that is more rapidly accessible than the memory area used to store the general file of VLAN tags **1108**.

Various factors may be used to establish the need for rapid access to certain VLAN identifier tags **1104**. Reliable communication with certain clients may be more critical than other clients, thereby requiring a more frequent status upgrade through the use of VLAN ping/echo packets **400**. Alternatively, certain clients may be known to receive more frequent transmissions from the server than others. For example, if the vital signs of a patient in intensive care were transmitted a monitoring room, the transmissions would be both frequent, and critical. According to the embodiment being discussed herein, before the server transmits a data packet **300**, the server must check the memory area memory to determine the status of the perspective client. To optimize computer speed and reduce the time invested in each status check, a status check being performed frequently would best be conducted if the respective VLAN identifier tag were in a cache type memory that could be accessed quickly.

According to one embodiment of the present invention, the cache **1103** would be static. In a static cache, upon booting, the computer would load the VLAN identifier tags **1104** of specific client computers into the cache **1103**, and they would remain in the cache **1103**. These VLAN tags **1104** would be selected for any number of properties such as critically of communication, or frequency of communication.

According to one embodiment, the cache **1103** is dynamic in nature. VLAN identifier tags **1104** stored in the cache memory **1103** would be constantly changing with tags **1110** stored in the general file of VLAN tags **1108**. The determination of which VLAN identifier tags **1104**, **1110** to move into or out of the cache is made by a cache management algorithm **1106**. Additionally, the cache management algorithm **1106** could control how frequently the status of a given tag need be updated. Factors used by the cache management algorithm might include, but would not be limited to: how long it has been since the last data transmission to a specific client computer, how many data transmissions incorporating a particular VLAN identifier tag had taken place over some specific time period, and a priority rating of a given tag.

Each VLAN identifier tag **1104** in the cache **1103** has a corresponding set of attributes. These attributes include, in the very least, the compliance-status of the various VLAN identifier tags **1104**. In the preferred embodiment, the attributes **1105** would also include the data necessary for effective operation of the cache management system **1106**. According to the preferred embodiment, attributes for VLAN tags **1104** stored in the cache would themselves be stored within the cache memory. It is however envisioned that select attributes could be stored in other areas of memory with pointers connecting them to the VLAN tags **1104** stored within the cache **1103**.

FIG. **12** depicts a flow chart of a dynamic or ongoing ping-echo memory update of client status. These steps are performed to establish client status at regular intervals as determined by a program (not shown). A memory update is performed, and any change in status may also be recorded. According to this embodiment, upon receipt of a message awaiting transmission, the server would confirm the client

status simply by examining the client status recorded in the server memory.

This embodiment can be used advantageously in an environment wherein a client computer which receives roughly one message per second. Transmitting a VLAN ping/echo packet every second prior to the data transmission would, in most instances, be unnecessary, and would unnecessarily burden a network with excess traffic. If the network were already near maximum capacity, and every message were preceded by a VLAN ping/echo packet, the number of communications across the network would effectively double, thereby overwhelming the network. Accordingly, the process disclosed in FIG. **12** is predicated upon a program generating VLAN ping/echo packets at an optimum rate that insures frequent update of client status while not burdening the network with unnecessary inquiries.

In step **1201** of FIG. **12**, a VLAN ping-echo manager (not shown) selects a VLAN identifier tag from memory.

In step **1202** of FIG. **12**, the VLAN tag is inserted into the header **406** of a packet containing an I.C.M.P. ping packet, forming a VLAN echo/ping packet **400**.

In step **1203** of FIG. **12**, The VLAN echo/ping packet **400** is transmitted onto the network **800**.

In step **1204** of FIG. **12**, the server **801** determines if an echo ping is received within a predetermined time. If an echo is received within the predetermined time, the client is determined to be compliant. If no echo is received in the allotted time, the client is determined to be non compliant. The time will configurable according to the needs of a given network. Although configurable to any length, in the preferred embodiment, the allotted time will be between 1 second and 255 seconds.

In steps **1205** and **1206**, the server memory is examined, and if necessary, the status of that particular VLAN identifier tag is upgraded changed. The memory upgrade is not limited to client status however, and includes all changes in memory resulting from the transmission of the VLAN ping/echo packet, including upgrading various cache attributes utilized in various embodiments of the present invention.

FIG. **13** depicts a flow chart wherein client status is checked before the transmission of each data packet. The utility of this process can be illustrated by considering a network wherein certain critical clients must be updated frequently, but other clients very infrequently. A memory structure as illustrated in FIG. **11** could be advantageously used in such a situation, with frequently updated VLAN tags stored in a static cache **1103**. The cache management algorithm **1106** would update the status of those VLAN tags at regular intervals prescribed by the cache management algorithm **1106**. On the other hand, clients that receive perhaps two messages per day need not be updated at frequent intervals. The VLAN tags for those clients would be stored in the general file of VLAN tags **1108**. In the case of these VLAN tags, a VLAN ping/echo packet being transmitted twice a day, just prior to transmission of the data packet, would burden the network far less than unnecessarily updating the status of these VLAN tags every seven to ten minutes.

According to the above example, it should be seen that the processes described in FIGS. **12** and **13** may be used simultaneously by the same server, and should not be construed as mutually exclusive.

In step **1301** of FIG. **13**, the server receives a packet for transmission onto the network. The packet may be generated from within the server, or received in transmission from another source.

In step **1302** of FIG. **13**, the packet is examined to determine if it is an approved protocol for the process disclosed in FIG. **13**. Because some networks are "closed," prohibiting non-approved protocols from being transmitted on the network, step **1302** is optional, and in many cases it will not be needed. If step **1302** is executed however and the packet is not approved, the program initiates step **1316**. If the packet is an approved protocol, the program initiates step **1303**.

In step **1316** of FIG. **13**, the microprocessor **101** terminates the process disclosed in FIG. **13**, and returns the microprocessor **101** to its next task.

In step **1303** of FIG. **13**, the packet is examined to determine if it has a VLAN tag. If the packet has a VLAN tag, the process advances to step **1304**. If the packet does not have a VLAN tag, the process advances to step **1312**. It is to be remembered that this process is not exclusive to VLAN tags, and can be applied to any network or sub-net identifier tag.

In step **1312** of FIG. **13**, the information in the packet is examined to determine if a VLAN tag can be generated from the data present in the packet. If such tag generation is possible the process advances to step **1313**. If tag generation is no possible, the process advances to step **1311**.

In step **1311** of FIG. **13**, the data packet is transmitted without a VLAN identifier tag.

In step **1313** of FIG. **13**, a VLAN tag **303** is generated from information contained in the packet **306**. The process then advances to step **1304**.

In step **1304** of FIG. **13**, the VLAN tag in the packet is compared to the status of that VLAN tag in the server memory. If the tag is found to be compliant, the process advances to step **1305**. If the tag is found to be non-compliant, the process advances to step **1308**.

In step **1308** of FIG. **13**, the VLAN tag **303** is inserted into a packet **306** containing in I.C.M.P. ping packet **304** in the data payload. The resultant packet is the VLAN ping/echo packet **400** disclosed in FIG. **4**.

In step **1309** of FIG. **13**, the server transmits the VLAN ping/echo packet **400** onto the network **814**.

In step **1310** of FIG. **13**, the server **801** determines if an echo ping is received within a predetermined time. If an echo is received within the predetermined time, the client is determined to be compliant, and the process advances to step **1315**. If no echo is received in the allotted time, the client is determined to be non compliant, and the process advances to step **1311** (discussed supra). Although configurable to any length, in the preferred embodiment, the allotted time will be between 1 second and 255 seconds.

In step **1315** of FIG. **13**, the server **801** performs a memory update. If a memory structure conforms closely to the embodiment disclosed in FIG. **9**, the update may be limited to checking the status of flags and updating flag status where necessary. If a memory structure conforming to the embodiment disclosed in FIG. **11** is utilized, the memory update may be more involved, comprising an update of various VLAN tag attributes, and, if the cache memory is dynamic in nature, possibly a file move of certain VLAN tags and attributes. The process then advances to step **1306**.

In step **1306** of FIG. **13**, the server transmits the data packet **300** with a VLAN tag **303** in the packet header **306**.

In step **1304** of FIG. **13**, the server examines the memory to determine if the VLAN tag **303** within the data packet **300** is found in memory. If it exists, the process advances to step **1305**. If no such VLAN tag exists in the computer memory,

the process advances to step **1308**. Alternatively, if no such tag is found to exist in memory, the process may terminate (path not shown), returning to step **1316**.

In step **1305** of FIG. **13**, the server determines if the VLAN tag **303** in the data packet **300** awaiting transmission is compliant by comparing it to the VLAN tags stored in the server memory. If the VLAN tag **303** is compliant, the process advances to step **1306** (discussed supra). If the VLAN tag **303** is non-compliant, the process advances to step **1307**.

In step **1307** of FIG. **13**, the server strips the VLAN tag **303** from the data packet **300**, and transmits a "tag-free" data packet **306**.

FIG. **14** depicts a flow chart for inserting a universal VLAN tag into data packets. The entire process disclosed in FIG. **14** is optional. The process involves inserting a "universal VLAN tag" into a packet header. The universal VLAN tag comprises a generic bit pattern that is the same size as the data field typically comprising a VLAN tag. The purpose of this process is to alter a transmission packet into a format recognizable by computers that are configured to respond exclusively to data transmissions comprising a VLAN tag in the header. The process disclosed in FIG. **14** is not concerned with options which depart from this goal. Accordingly, the affirmative paths extending from steps **1402** and **1403**, which were already developed in FIG. **13**, are not duplicated in FIG. **14**.

In step **1401** of FIG. **14** the server receives a data packet that is to be transmitted onto the network. The data packet may have been generated within the server itself, or may have been received in transmission. Following step **1401**, the process advances to step **1402**.

In step **1402** of FIG. **14**, the server determines if the data packet has a VLAN tag in the header. If no tag is present, the process advances to step **1403**.

In step **1403** of FIG. **14**, the server determines whether or not a VLAN tag can be generated from data already present in the packet. If no VLAN tag can be generated, the process advances to step **1404**.

In step **1404** of FIG. **14**, the server determines whether the intended recipient of the data transmission is VLAN tag-compliant. If compliance is unlikely, the process advances to step **1405**. If compliance is believed likely, the process advances to step **1406**. Factors used in determining the likelihood of compliance are determined by the individual programmer, as is the algorithm used to determine compliance. Such decision making algorithms are commonly known to those skilled in the art.

In step **1405** the data packet is transmitted without a VLAN tag.

In step **1406** the sever inserts a universal VLAN tag into the header of the data packet.

In step **1407** the server transmits the packet.

It should be understood that the process as disclosed in FIG. **14** should not be construed as to prohibit dual transmission of the same message in different formats, including a "tag-less" packet and a packet containing a universal VLAN tag. Although dual paths have not been included in FIG. **14**, it is understood that such an option, though not shown, is available if it were expedient for a given network.

It should further be understood that any of the various steps or processes disclosed in FIGS. **12**, **13** and. **14** may be omitted if they do not conform to the objectives or capabilities of the network server. Similarly, it is to be understood that the specification of certain steps in FIGS. **12**, **13** and **14** does not preclude the inclusion of additional steps therein.

What is claimed is:

1. In a server computer comprising a processor, a memory, said server computer communicatively coupled to a plurality of client computers in a network, a method for detecting reachability of client computers comprising:

storing a first reachability file comprising a plurality of records, wherein each record indicates a status of each "compliant" client computer;

storing a second reachability file comprising a plurality of records, wherein each record indicates a status of each "non-compliant" client computer

generating a first data packet with an I.C.M.P. packet for a data payload;

selecting a first identifier tag from among a select plurality of identifier tags stored within said first reachability file or said second rechability file;

inserting said first identifier tag into a proper data segment of said first data packet, thereby forming a first tagged ping packet;

transmitting said first tagged ping packet to a first client computer;

determining whether said first client computer is "compliant" or "non-compliant" from a response to said first tagged ping packet;

moving one of said plurality of records of said first reachability file, corresponding to said first client computer, to said second reachability file if said first client computer is determined to be "non-compliant" ; and

moving one of said plurality of records of said second reachability file, corresponding to said first client computer, to said first reachability file if said first client computer is determined to be "compliant".

2. The method for detecting reachability of clients according to claim **1**, further comprising deriving said first identifier tag from an incoming message prior to inserting said first identifier tag into said first data packet.

3. The method for detecting reachability of clients according to claim **1**, further comprising:

receiving a subsequent message containing an incoming identifier tag;

searching said first reachability file for said incoming identifier tag;

determining the status of said incoming identifier tag from said first reachability file;

providing said incoming identifier tag is "compliant", re-transmitting said subsequent message; and

providing incoming identifier tag is "non-compliant", removing said incoming identifier tag from said subsequent message and re-transmitting said subsequent message without an identifier tag.

4. The method for detecting reachability of clients according to claim **1**, further comprising:

receiving a subsequent message lacking an identifier tag;

generating an identifier tag from data contained in said subsequent message;

determining the status of said generated identifier tag comparing said generated identifier tag to said select plurality of identifier tags stored within in said first reachability file or said second reachability file;

providing said generated identifier tag is "compliant", inserting said generated identifier tag into said subsequent message and re-transmitting said subsequent message; and

providing said generated identifier tag is "non-compliant", re-transmitting said subsequent message without an identifier tag.

5. The method for detecting reachability of clients according to claim **1**, further comprising:

receiving a subsequent message lacking an identifier tag;

inserting a universal identifier tag into a proper data segment of said message; and

re-transmitting said subsequent message.

6. The method for detecting reachability of clients according to claim **1**, wherein:

said memory comprises a cache type memory;

said method further comprises;

selecting a first priority record from said select plurality of records in said first reachability file or said second reachability file; and

storing said first priority record in said cache type memory.

7. The method for detecting reachability of clients according to claim **6**, wherein said cache type memory is static.

8. The method for detecting reachability of clients according to claim **6**, wherein said cache type memory is dynamic, said server computer further comprising a cache management algorithm and a first set of attributes corresponding to said first priority identifier tag in said cache type memory.

9. The method for detecting reachability of clients according to claim **1**, wherein said network comprises a heterogeneous mix of "compliant" and "non-compliant" client computers.

10. The method for detecting reachability of clients according to claim **1**, wherein said identifier tag is an 802.1 q/P identifier tag.

11. A networked server system comprising:

a server computer comprising;

a server memory for storing a first and second reachability file each comprising a plurality of records, wherein each record comprises a tag identifier corresponding to one of a plurality of client computers;

a server processor operatively connected to said server memory, for performing a process comprising;

selecting a first identifier tag from among a select plurality of identifier tags stored within said first reachability file or said second rechability file;

inserting said first identifier tag into a proper data segment of said first data packet, thereby forming a first tagged ping packet;

transmitting said first tagged ping packet to a first client computer;

determining whether said first client computer is "compliant" or "non-compliant" from a response to said first tagged ping packet;

moving one of said plurality of records of said first reachability file, corresponding to said first client computer, to said second reachability file if said first client computer is determined to be "non-compliant";

moving one of said plurality of records of said second reachability file, corresponding to said first client computer, to said first reachability file if said first client computer is determined to be "compliant";

receiving a subsequent message containing an incoming identifier tag;

determining the status of said incoming identifier tag by comparing said incoming identifier tag to a select plurality of identifier tags stored within said first reachability file or said second reachability file;

providing said incoming identifier tag is "compliant", re-transmitting said subsequent message; and

providing said incoming identifier tag is "non-compliant", removing said incoming identifier tag from said subsequent message and re-transmitting said subsequent message without an identifier tag; and

at least one transmission port operatively connected to said server processor; and

said first client computer comprising;

a client processor; and

a client transmission port operatively connected to said client processor; and

a transmission means operatively connecting said at least one transmission port of said server to said transmission port of said client.

12. The server computer system according to claim **11**, wherein said processor performs said process further comprises deriving said first identifier tag from an incoming message prior to inserting said first identifier tag into said first data packet.

13. The server computer system according to claim **11**, wherein said processor performs said process farther comprising:

receiving a subsequent message lacking an identifier tag;

generating an identifier tag from data contained in said subsequent message;

determining the status of said generated identifier tag by comparing said generated identifier tag to a select plurality of identifier tags stored within said first reachability file or said second reachability file;

providing said generated identifier tag is "compliant", inserting said generated identifier tag into said subsequent message and re-transmitting said subsequent message; and

providing said generated identifier tag is "non-compliant", re-transmitting said subsequent message without an identifier tag.

14. The server computer system according to claim **11**, wherein process further comprises:

receiving a subsequent message lacking an identifier tag;

inserting a universal identifier tag into a proper data segment of said subsequent message; and

re-transmitting said subsequent message.

15. The server computer system according to claim **11**, wherein:

said server computer further comprises a cache type memory; and

said process further comprises;

selecting a first priority record from said plurality of records; and

storing said first priority record in said cache type memory.

16. The server computer system according to claim **15**, wherein said cache type memory further comprises a first set of attributes, said first set of attributes corresponding to said first priority identifier tag.

17. The server computer system according to claim **11**, wherein said systems network comprises a heterogeneous mix of "compliant" and "non-compliant" client computers.

18. The server computer system according to claim **12**, wherein said identifier tag is an 802.1 q/P identifier tag.

19. A computer-readable medium containing a plurality of instructions which when executed cause a server computer

to implement a method for detecting reachability of a client computer comprising:

generating a first data packet within said server computer, said data packet having an I.C.M.P. packet for a data payload;

selecting a first identifier tag from among a plurality of identifier tags stored in a select one of a first or second reachability file;

inserting a first identifier tag into a proper data segment of said first data packet, thereby forming a first tagged ping packet;

transmitting said first tagged ping packet to a first client computer;

determining an updated status of said first client computer as "compliant" or "non-compliant" from a response to said first tagged ping packet;

moving one of a plurality of records of said first reachability file, corresponding to said first client computer, to said second reachability file if said first client computer is determined to be "non-compliant";

moving one of a plurality of records of said second reachability file, corresponding to said first client computer, to said first reachability file if said first client computer is determined to be "non-compliant".

20. The computer-readable medium according to claim **19**, further comprising deriving said first identifier tag from an incoming message prior to inserting said first identifier tag into said first data packet.

21. The computer-readable medium according to claim **19**, further comprising:

receiving a subsequent message containing an incoming identifier tag;

determining the status of said incoming identifier tag by comparing said incoming identifier tag to said select plurality of identifier tags stored within said first reachability file or said second reachability file;

providing said incoming identifier tag is "compliant", re-transmitting said subsequent message; and

providing said incoming identifier tag is "non-compliant", removing said incoming identifier tag from said subsequent message and re-transmitting said subsequent message without an identifier tag.

22. The computer-readable medium according to claim **19**, further comprising:

receiving a subsequent message lacking an incoming identifier tag;

generating a generated identifier tag for said subsequent message from data in said subsequent message;

comparing said generated identifier tag to said select plurality of identifier tags stored within said first reachability file or said second reachability file;

determining the status of said generated identifier tag by comparing said generated identifier tag to said select plurality of identifier tags in said first reachability file or said second reachability file;

providing said generated identifier tag is "compliant", inserting said generated identifier tag into said subsequent message and re-transmitting said subsequent message; and

providing said generated identifier tag is "non-compliant", re-transmitting said subsequent message without an identifier tag.

23. The computer-readable medium according to claim **19**, further comprising:

receiving a subsequent message lacking an incoming identifier tag;

inserting a universal identifier tag into a proper data segment of said subsequent message; and

re-transmitting said subsequent message.

24. The computer-readable medium according to claim **19**, further comprising:

selecting a first priority record from said select plurality of records stored within said first reachability file or said second reachability file; and

storing said first priority record in a cache type memory.

25. The computer-readable medium according to claim **24**, said cache type memory is static.

26. The computer-readable medium according to claim **24**, wherein said cache type memory is dynamic, and further comprising a cache management algorithm and a first set of attributes corresponding to said first priority identifier tag in said cache type memory.

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